LAND GRID ARRAY (LGA) INTERPOSER WITH ADHESIVE-RETAINED CONTACTS AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to integrated circuit mounting systems, and more particularly, to an interposer for mounting Land Grid Array (LGA) integrated circuits to an electronic assembly and a method of manufacturing the interposer.

2. Background Information

Land Grid Array (LGA) integrated circuits are in widespread use in electronic systems. The LGA interconnect scheme provides a high interconnect-density electronic interface that also provides a highly-reliable socket interconnect structure that permits mounting of semiconductor packages having a large thermal expansion with respect to an electronic assembly mounting area such as a Printed Circuit Board (PCB). For example, ceramic semiconductor packages generally have a much lower coefficient of thermal expansion than PCBs and so typical solder-ball mounting such as with Ball Grid Array (BGA) leads to fracture of the solder ball connections when temperatures vary widely, causing failure of the electronic system.

The LGA interconnect also permits interchangeable integrated circuit mounting without using pin-based interconnects. For example, in present-day computing systems, processing components are often mounted using a socket configuration rather than mounted via a solder interconnect so that the processing components may be selected and installed after an electronic assembly such as a "motherboard" has been fabricated.

In order to provide a reliable and low resistance electrical connection between the LGA integrated circuit and an electronic assembly such as a printed wiring board (PWB), LGA interposers have been developed that typically use a loaded spring contact or a "fuzz button" contact at each contact position that extend from the lands on the integrated circuit to a land on the electronic assembly. Both types of contacts in present use are typically gold-plated to provide a low-resistance connection that is resistant to environmental degradation such as oxidation.

The fuzz buttons or spring contacts are inserted into a mounting frame that is generally a rectangular plastic interposer frame having circular holes at each contact position. After the contacts are inserted, the interposer assembly is complete. In use, the interposer is placed and aligned between the LGA integrated circuit and the electronic assembly and the LGA integrated circuit is secured with a mounting mechanism that applies pressure between the LGA integrated circuit and the electronic assembly. The pressure compresses the fuzz buttons or spring contacts, providing a reliable electrical interconnect between the LGA lands on the integrated circuit and the lands on the electronic assembly.

However, the retention of either fuzz button contacts or spring contacts in the interposer frame has presented a manufacturing and post-manufacturing handling and reliability problem, as the contacts may fall out of or move from their proper positions in the interposer frame during handling of the interposer or assembly of the LGA to the electronic assembly. Even after assembly, vibration or other stresses may cause movement of the contacts causing a failed interconnect or a short due to lateral contact of the LGA interposer contacts above or

below the surfaces of the interposer frame.

Also, rigid securing of LGA interposer contacts is not desirable, as ideally, the contacts should be permitted to "float" so that thermal expansion differences between the LGA integrated circuit package and the electronic assembly do not cause an interconnect failure due to compression unloading of one end of a contact or possible overloading and deformation of a contact that will subsequently disconnect when the temperature changes. One securing scheme that has been implemented for retaining LGA contacts uses hourglass-profiled voids in the interposer frame into which the contacts are inserted. The "neck" points of the voids slightly compress the contacts laterally, so that the contacts are more securely retained in the interposer frame. However, the contacts may still move or fall out of the interposer if sufficient force is applied.

Therefore, it would be desirable to provide a mechanism and method of manufacture for securely retaining both fuzz button and spring contacts in a LGA interposer frame that still allows the contacts to float.

SUMMARY OF THE INVENTION

The objective of providing a secure mechanism for retaining LGA interposer contacts in an interposer frame is accomplished in a new LGA interposer and method of manufacture.

The interposer includes an interposer frame having a grid of holes that may be cylindrical or may have other profiles. A contact, which may be a spring contact or a fuzz button type contact is inserted in each hole and is secured with an elastomeric adhesive. The elastomeric adhesive provides sufficient flexibility so that the contacts may still float in response to an applied force, providing a secure electrical connection, but prevents permanent migration of the contacts from the desired position. In the case of spring contacts, a self-healing adhesive may be deposited within the holes and the spring contacts inserted after curing of the adhesive.

The foregoing and other objectives, features, and advantages of the invention will be apparent from the following, more particular, description of the preferred embodiment of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein like reference numerals indicate like components, and:

Figure 1A is a pictorial diagram depicting a cross-section of an LGA interposer assembly in accordance with an embodiment of the present invention.

Figure 1B is a pictorial diagram depicting a cross-section of an LGA interposer assembly in accordance with another embodiment of the present invention.

Figure 2A is a pictorial diagram depicting a perspective view and detail of LGA interposer **5** of **Figure 1A**.

Figure 2B is a pictorial diagram depicting a perspective view and detail of LGA interposer **5** of **Figure 1B**.

Figure 3 is an illustration depicting a manufacturing process for making an LGA interposer in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention will now be described in more detail by way of example with reference to the embodiments shown in the accompanying figures. It should be kept in mind that the following described embodiments are only presented by way of example and should not be construed as limiting the inventive concept to any particular physical configuration.

Further, if used and unless otherwise stated, the terms "upper," "lower," "front," "back," "over," "under," and similar such terms are not to be construed as limiting the invention to a particular orientation. Instead, these terms are used only on a relative basis.

The present invention is directed toward an interposer for land grid array (LGA) semiconductor package mounting that provides improvement in retention of contacts within the interposer frame.

With reference now to the figures, and in particular with reference to **Figure 1A**, there is depicted an LGA interposer **5** in accordance with an embodiment of the present invention. Interposer **5** is used to interconnect a semiconductor package **16** having a plurality of LGA terminals **17** to lands **15** on a system substrate **14**, such as a printed circuit board. Interposer **5** provides electrical connection between each of LGA terminals **17** and a corresponding land **15** via a plurality of electrically-conductive contacts **11**. In the depicted embodiment, contacts **11** are c-shaped spring contacts formed from stamped, bent and plated metal. Contacts **11** are held in position along the plane of the grid array by an interposer frame **10** that has a through-hole (void) **12** for each contact **11** and into which each contact **11** is

inserted. Pressure is provided between semiconductor package **16** and system substrate **14** by a clamping arrangement such as spring clip **18**. The pressure on contacts **11** causes compression of contacts **11**, providing a secure electrical connection.

However, as described above with respect to the prior art, contacts **11** may not be under uniform pressure, are subject to vibration and may move prior to securing interposer **5** between semiconductor package **16** and system substrate **14**, causing contacts **11** to fall out completely or extend so far as to bend and cause intermittent connections, missing connections or shorts to adjacent contacts. If contacts **11** were rigidly secured to interposer frame **10**, differential thermal expansion or differences in mechanical pressure across interposer **5** could lead to missed wiping of contacts **11** on lands **17** or **15**. Therefore, an elastic adhesive **13** is introduced to retain contacts **11** within holes **12** so that contacts **11** may move in a direction perpendicular to the primary plane of interposer frame **10** while keeping contacts **11** from falling out or moving far enough to cause shorting to adjacent contacts or lands.

Elastic adhesive **13** is generally a silicone or urethane adhesive that is either a two-part adhesive mixed at the time of application, or may be a UV or temperature curable adhesive.

While the above-described use of LGA interposer **5** is in a connection between an LGA semiconductor package and a printed circuit board land pattern, it should be understood that other LGA or grid array applications are possible such as board-to-board interconnects. Further, while LGA is a particular technology subject to certain standards in the art, it should be understood that the present invention applies to interposers and

sockets having floating contacts that are not typically mechanically secured to the frame in order to provide a wide range of thermal and pressure variation between two subsystems that are connected. The present invention provides a means and method by which such interposer and socket systems may be improved in reliability and ease of handling/installation.

Referring now to **Figure 1B**, there is depicted a Land Grid Array (LGA) interposer **5A** in accordance with another embodiment of the present invention. As described above with respect to Figure 1A, Interposer **5A** is used to interconnect a semiconductor package **16** having a plurality of LGA terminals **17** to lands **15** on a system substrate **14**, such as a printed circuit board. Interposer **5A** provides electrical connection between each of LGA terminals **17** and a corresponding land **15** via a plurality of electrically-conductive contacts **11A**. In the depicted embodiment, contacts **11A** are "fuzz buttons" formed from a single strand of molybdenum wire spun into a compressible cylindrically-shaped electrically conductive contact. Contacts **11A** are held in position along the plane of the grid array by an interposer frame **10A** that has a through-hole (void) **12A** for each contact **11A** and into which each contact **11A** is inserted. Holes **12A** are depicted as having an hourglass-shaped cross-section that is typically used to improve retention of contacts **11A**. However, with the advantages of the present invention, it is not necessary to provide such an hourglass profile in order to retain contacts **11A**, although assembly may be simplified. As in the embodiment depicted in Figure 1A, pressure is provided between semiconductor package **16** and system substrate **14** by a clamping arrangement such as spring clip **18**. The pressure on contacts **11A** causes compression of contacts **11A**, providing a secure electrical

connection.

However, as described above with respect to Figure 1A, contacts **11A** may not be under uniform pressure, are subject to vibration and may move prior to securing interposer **5A** between semiconductor package **16** and system substrate **14**, causing contacts **11A** to fall out completely or extend so far as to bend and cause intermittent connections, missing connections or shorts to adjacent contacts. Further, fuzz button contacts such as contacts **11A** can be deformed or may actually unwind, increasing the likelihood of shorting if an end of the wire forming a fuzz button leaves the area of void **12A**. Elastic adhesive **13A** is introduced to retain contacts **11A** within holes **12A** so that contacts **11A** retain their shape and do not unwind. Also, elastic adhesive **13A** provides movement in a direction perpendicular to the primary plane of interposer frame **10A** while keeping contacts **11A** from falling out or moving far enough to cause shorting to adjacent contacts or lands. The combination of preventing unwinding and restricting movement of fuzz button contacts **11A**, substantially eliminates the possibility of shorting due to migration or unwinding of contacts **11A**.

Referring now to **Figure 2A**, interposer **5** is shown in further detail. In the depiction, the location of holes **12** through interposer frame **10** forming a grid array can be seen. Callout **30** shows a magnified detail of a contact **11** secured by adhesive **13** within hole **12**. While holes **12** are of a dumbbell shape for accepting c-shaped spring contacts **11**, it should be understood that the shape of holes **12** is incidental to the purpose of the present invention, although in the depicted embodiment, the dumbbell-shaped holes may provide better retention of contacts **11** by adhesive **13** when adhesive is disposed within the body of contacts **11** by shortening the distance between the body of

contacts **11** and the walls of holes **12**.

For spring contact interposers in accordance with the present invention such as interposer **5**, interposer frame **10** may be prepared with elastic adhesive **13** prior to insertion of contacts **11**. By using a self-healing adhesive compound and curing the compound prior to insertion of contacts **11**, contacts **11** may be retained by insertion displacement of adhesive **13** without adhesive **13** adhering (bonding) to contacts **11**. Adhesive **13** may be applied via a paste and wipe operation, but may be alternatively applied only within interposer frame **10** by injection in a central portion of holes **12** so that adhesive **13** does not reach the top or bottom surface of interposer frame **10**. Alternatively, contacts **11** may be inserted through uncured adhesive **13** that has been injected into holes **12** and adhesive then cured, so that adhesive **13** adheres to contacts **11**.

As another alternative, interposer **5** may be assembled by loading contacts **11** in holes **12** and then injecting adhesive **13** in holes **12** in order to bond adhesive **13** to both the inner walls of holes **12** and to contacts **11**. Generally, for a c-shaped contact **11** such as those depicted in Figure 1A, adhesive **13** is injected so that the central void in the body of contact **11** is filled with adhesive **13** that is also bonded to the walls of hole **12**. However, adhesive **13** may be applied only to the periphery of hole **12** or a portion thereof that is adjacent a surface of contact **11**, depending on the amount of resistance to displacement of contact **11** that is needed.

Referring now to **Figure 2B**, interposer **5A** is shown in further detail. In the depiction, the location of holes **12A**

through interposer frame **10A** forming a grid array can be seen. Callout **32** shows a magnified detail of a contact **11A** secured by adhesive **13A** within hole **12A**.

For fuzz button contact interposers in accordance with the present invention such as interposer **5A**, interposer **5A** may be assembled by loading contacts **11A** in holes **12A** and then injecting adhesive **13A** in holes **12A** in order to bond adhesive **13A** to both the inner walls of holes **12A** and to contacts **11A**. Alternatively, adhesive may be injected into holes **12A** and contacts **11A** inserted before curing adhesive **13A**. Generally, for a fuzz button contact **11A**, adhesive **13A** is injected around the periphery of the walls of hole **12** at least near the surfaces of the interposer frame **10A**, which helps maintain the shape of contacts **11A** as described above. The above-described process can be performed on prefabricated fuzz button interposers. However, adhesive **13A** may be applied only to the interior of hole **12A**, depending on the amount of resistance to displacement of contact **11A** that is needed and the amount of control of the shape of contact **11A** near the outside surfaces of interposer frame **10A**.

Referring now to **Figure 3**, the methods of manufacture of the various interposers described above are illustrated. An adhesive dispensing system is used to introduce elastic adhesive into interposer frame **10** holes **12**. Interposer frame **10** is generally held in an X-Y positioning table with a fixed dispensing needle location or may be held in a fixed position and the dispensing needle is moved as will be illustrated. The adhesive dispensing system comprises a positioner **40** for moving a dispenser **44** that terminates in a needle **42** for injecting adhesive into holes **12**. By controlling the position of needle **42** and amount of adhesive dispensed at each hole **12** the proper amount of resistance to

displacement (and deformation in the case of fuzz button contacts) can be maintained. When adhesive is injected prior to insertion of contacts, a needle of appropriate size for quickly filling each hole **12** to between 10% and 100% of the hole volume at each step position (hole location) of positioner **40** is used. An adhesive of fairly high viscosity is used to retain the adhesive in holes **12** prior to curing. But, when injecting adhesive after insertion of contacts, a small needle (approximately 30ga) is used so that adhesive can be injected around or into the contacts. A low viscosity adhesive is also necessary when contacts are pre-inserted so that the adhesive can wick into the open volumes within holes **12**.

It should be understood, however, that the invention is not necessarily limited to the specific process, arrangement, materials and components shown and described above, but may be susceptible to numerous variations within the scope of the invention.

It will be apparent to one skilled in the art that the manner of making and using the claimed invention has been adequately disclosed in the above-written description of the preferred embodiments taken together with the drawings.

It will be understood that the above description of the preferred embodiments of the present invention are susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.